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THERMAL TEST WINDOW ASSEMBLY

MK-II

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INTRODUCTION

The thermal test window assembly is designed to provide a means of experimentally measuring the heat flow through such an assembly when subjected to the thermal environment simulating that anticipated in actual use. Although the final window which will be used in the vehicle may differ appreciably from this test model in physical appearance, it is anticipated that the heat flow characteristics of the two units shall be similar. It is hoped that data obtained in testing this and similar units will contribute to the refinement of the final design; as well as provide the information necessary to establish air conditioning loads, cooling requirements, and Q-bay environment specifications.

The thermal test window is designed to provide maximum flexibility in testing. It can be used as a three glazing configuration, with and without cooling air; and by removal of the inner glazing assembly, it can be used as a two glazing configuration.

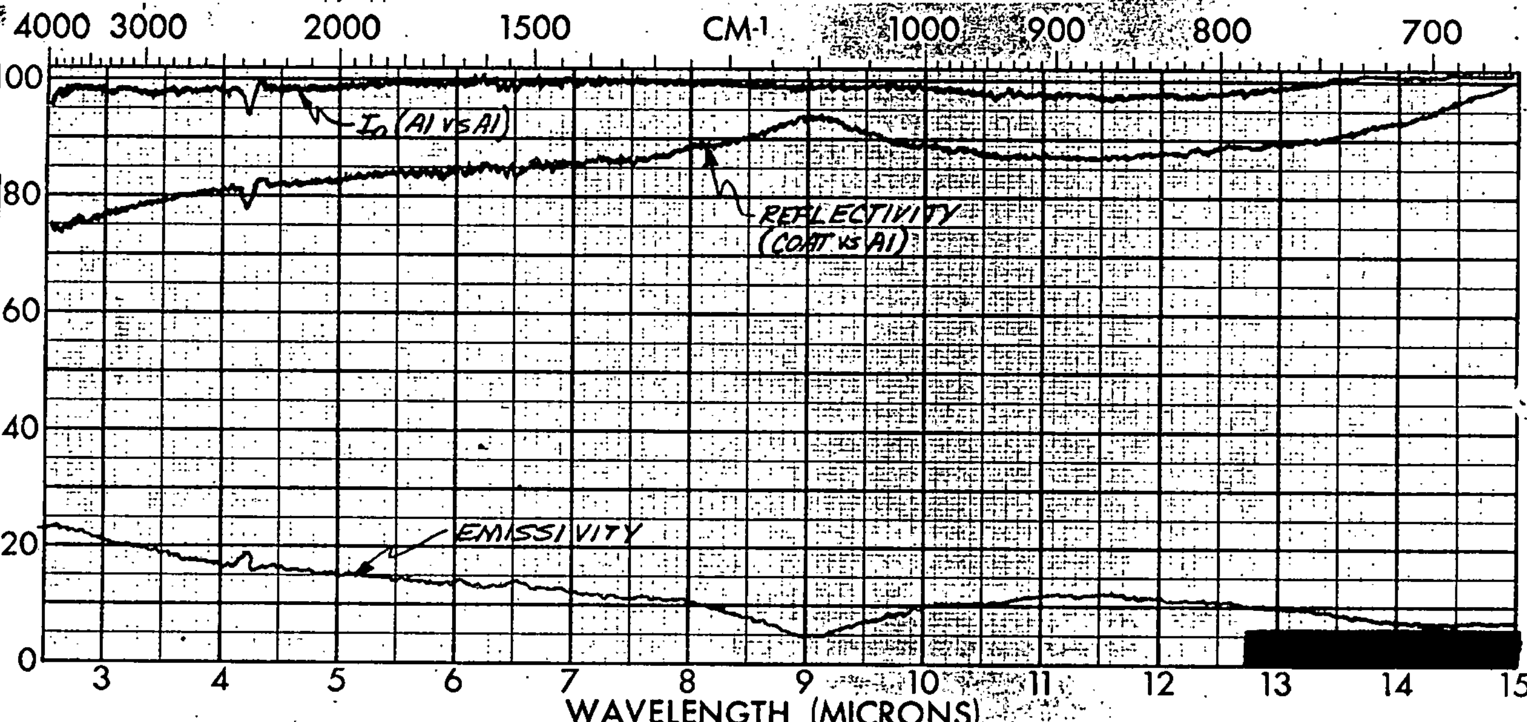
It is the purpose of this report to describe in detail the proper operation and utilization of the test configuration; and to list the salient physical characteristics of the assembly, so that analytical calculations can be made.

WINDOW ASSEMBLY

The window assembly consists of three glazings. The outer glazing is 0.65" fused silica, the middle glazing is 0.75" fused silica, and the inner glazing is 0.50" BK-7. Fused silica was used for the outer and middle glazings because of its strength and its capability of withstanding severe thermal stresses.

In order to retard heat penetration through the assembly, two surfaces of the glazing are coated with a low emissivity coating, described in Figure 1. In addition, a vacuum between the outer and middle glazing acts as an insulator. The outer and middle glazings are essentially freely supported rectangular plates which, because of the vacuum gap, are uniformily loaded by atmospheric pressure.

The design value which was used for the modulus of rupture of fused silica was about 5000 psi and for BK-7 was about 3200 psi. The design safety factor reduces the design stresses for silica and BK-7 to 3300 psi and 2100 psi respectively. The total stresses on the face of each glazing consists of the stresses due to the pressure difference between faces, plus (or minus) the stresses due to temperature gradients. The pressure stresses remain constant during this particular test because the ambient (atmospheric) pressure does not change. The thermal stresses will add to or subtract from the pressure stresses depending on whether the stresses are due to cooling (tensile) or heating (compressive).



[redacted]

SPECTRUM NO. 105	ORIGIN	LEGEND	REMARKS
SAMPLE LOW		1.	1-R = ε
EMISSIVITY COATING	PURITY	2.	SiO_2 COAT R
	PHASE	DATE 19 SEPT 1960	
	THICKNESS	OPERATOR AWB	

SPECTRUM NO.
SAMPLE

Page 3

FIGURE 1

[redacted]

 [redacted]

The window assembly was designed to operate at sea level pressure for the complete duration of the heat test. The pressure in the cooling air gap must never exceed 1 psig. The cooling air temperature must never be less than 80°F. When cooling air is to be used as part of the heat test, it must be turned on prior to the start of the heating cycle. Cooling air should never be turned on after a heat test has started.

No part of the assembly should ever be subjected to temperatures greater than 515°F. The assembly was designed to withstand the heating and cooling profile delineated in a memorandum from the vehicle manufacturer dated 29 February 1960. The heating and cooling rates correspond to approximately 50°F/min. on the outer glazing surface.

Drawing 547-0193-2 is an assembly drawing of the window. The O-rings used to accomplish the vacuum seal are a compound of Viton A and B. In operation, the high temperatures involved will cause the O-rings to take a set. After prolonged operation the O-ring will seal itself to the quartz glazing, making removal difficult. Attempting to change the O-ring may result in damage to the low emissivity coatings. It is suggested that if a leak develops in the vacuum seal, that the unit not be disassembled, but that it be returned to us for servicing.

Since a compressible O-ring is used, when vacuum is applied, one glazing will withdraw into the mount. If it is necessary, the lower retainer ring may then be tightened to eliminate the space between the faying surfaces of the withdrawn glazing and the frame. However, the mount should be loosened

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before the vacuum is released, since it is not designed to withstand the loading which would result. As the O-ring takes a set, the amount of gap will become smaller. Maintaining a slight compression of the O-ring, by means of the mount retainer, when the unit is not evacuated may be desirable, since it will prevent dirt from entering the sealing surfaces of the O-ring.

The surfaces of each glazing are optically polished. Extreme caution should be taken in the handling and cleaning of the glazing surfaces. Even though the exposed surfaces are in compression, thermally induced strains coupled with a scratch may result in fracture. Cleaning should be accomplished using acetone and lens tissue in a manner consistant with good optical practice. Caution should be exercised so as not to deteriorate the silastic seal or Viton O-rings with the acetone. If the acetone is applied sparingly on a pad of tissue, not enough will contact the rubber to cause harmful effects.

The thermocouples are attached to the glazings with Saueroisen No. 29 cement, and are located as shown in Figure 2. The thermocouples are numbered to correspond to the numbering system used on the thermal test window assembly retained at our location. Therefore corresponding numbers refer to thermocouples at the same location on both units. The terminal board arrangement is shown in Figure 3.

THERMOCOUPLE LOCATION AND IDENTIFICATION

TOP VIEW

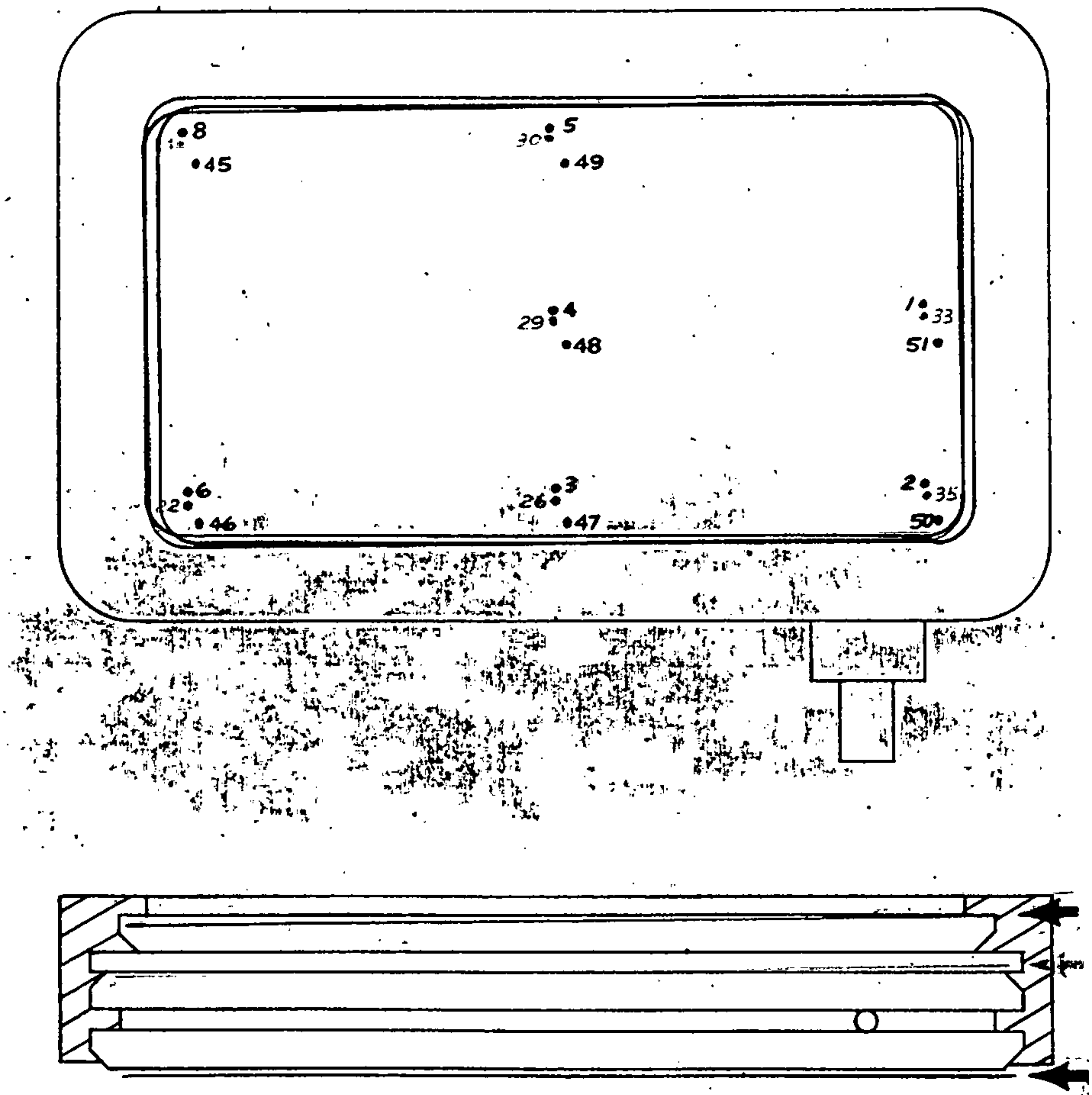
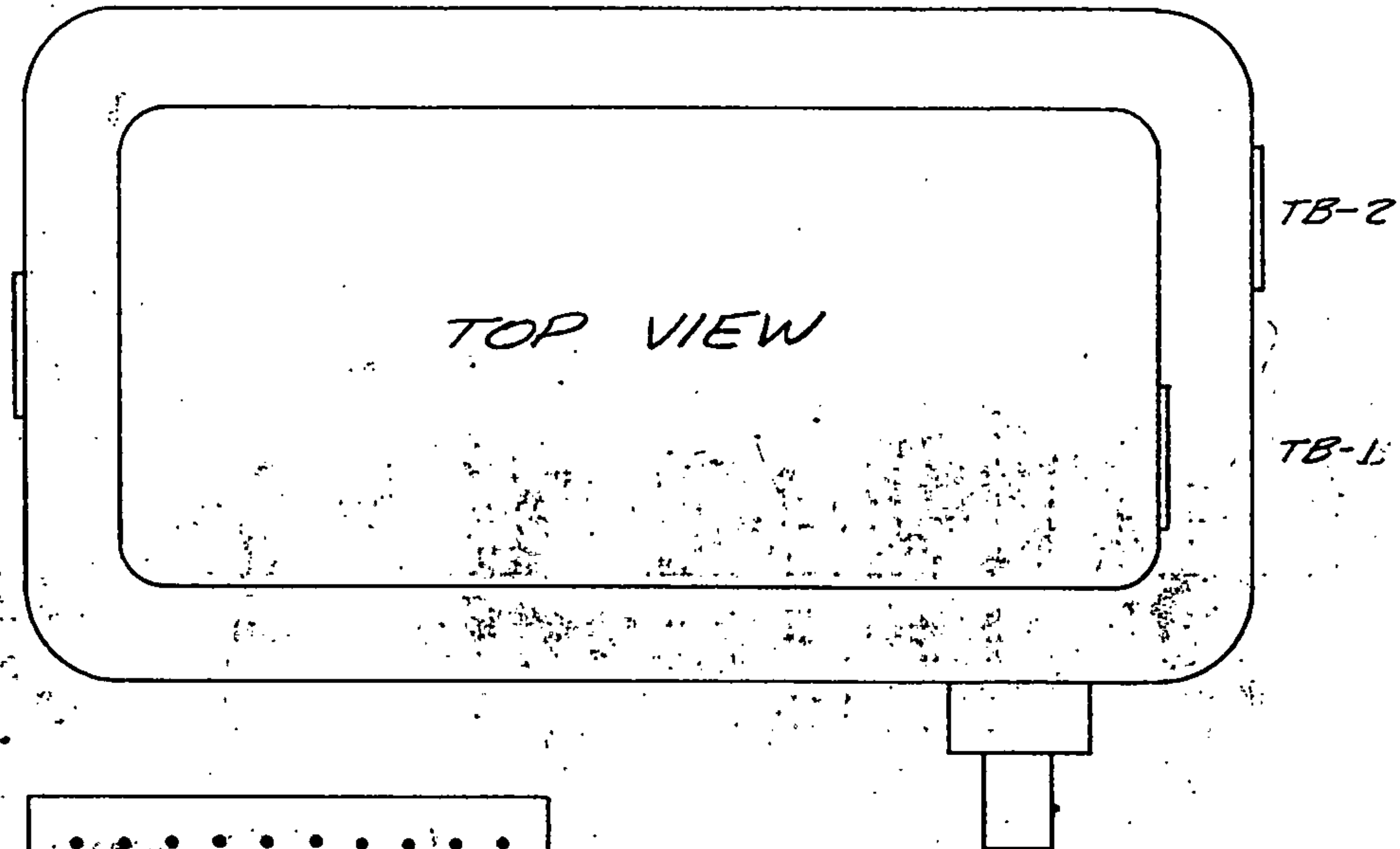
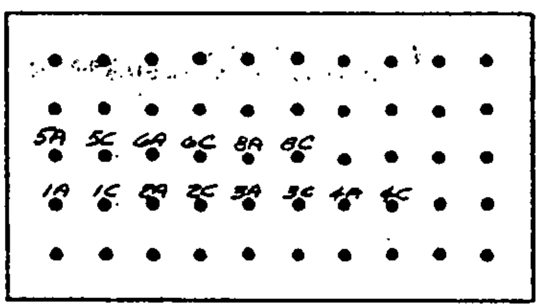


FIGURE 2

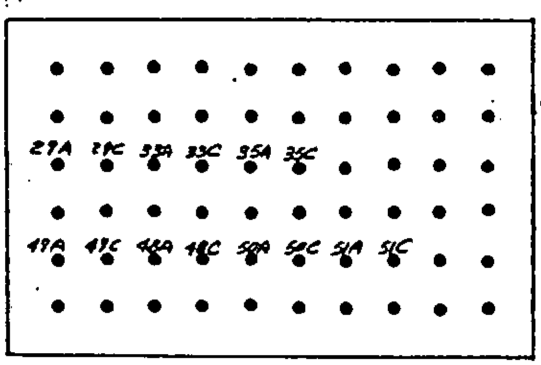
THERMOCOUPLE LOCATION ON TERMINAL BOARDS



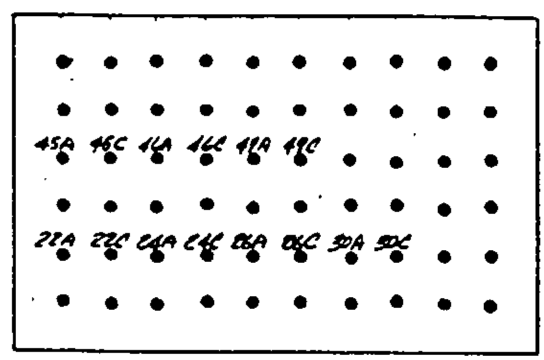


TB-1

"A" DESIGNATES ALUMEL
"C" DESIGNATES CHROMEL



TB-2



TB-3

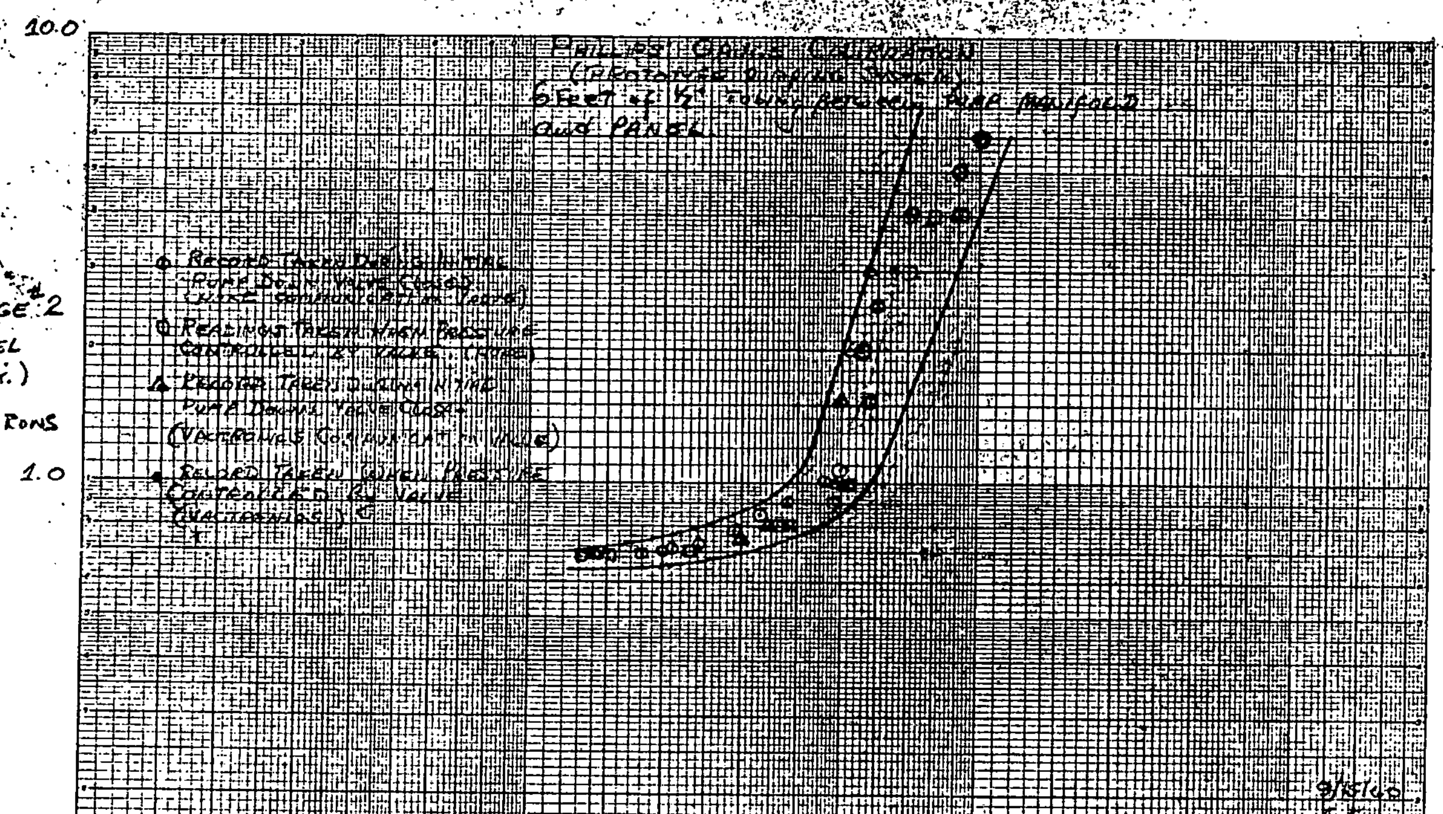
NOTE: VIEW OF TERMINAL BOARDS AS SEEN FROM OPPOSITE FACE THAN THAT TO WHICH THERMOCOUPLES ARE ATTACHED.

VACUUM SYSTEM

The purpose of maintaining a vacuum in the gap between the outer two glazings is to reduce heat transfer by conduction through this gap. The thermal conductivity of air is essentially independent of pressure at high pressures, and varies linearly with pressure at very low pressures. The transition range is dependent upon geometry. For the configuration of the vacuum gap, a pressure of at least 2 microns must be maintained in order to produce adequate thermal insulation.

Because of orifice restrictions in the spacer and valves, the vacuum gage located on the pumping system manifold will not include the actual pressure in the vacuum gap. A calibration was established by using a second vacuum gage mounted in a metal plate which was substituted for one of the glazings. The gage at the manifold was separated from the configuration by 6 feet of ½ inch copper tubing, and by two valves with orifice restrictions of 0.170 and 0.375 inches. The calibration is shown in figure 4, and indicates that a pressure no greater than 0.5 microns should be maintained at the manifold location.

If the vacuum gap is exposed to air, it may require several hours of baking at 500°F, with continuous vacuum pumping, for sufficient outgassing to occur to enable the desired pressure to be achieved in the vacuum gap. Even though the unit will be shipped with a vacuum in the vacuum gap, the outgassing procedure will probably be required initially.



GAUGE #2
PANEL
ASSY.)
MICRONS
10.0
1.0
0.10
0.01
0.10
1.0
10.0
MICRONS
GAUGE #1
(PUMP MANIFOLD)

FIGURE 4.

VACUUM SYSTEM OPERATING INSTRUCTIONS

1. Components

1.1. Vacuum pumps

1.1.1. Mechanical pump:

Central Scientific Company

Type No. HYVAC-2

Operating range from atmospheric pressure (760 mm of Hg) to approximately one micron (1×10^{-3} mm of Hg)

1.1.2. Diffusion pump:

Consolidated Vacuum Corporation

Type No. VMF-11

Operating range from 10^{-1} mm of Hg to 10^{-6} mm of Hg

Heater coil input at 135 watts.

1.2. Pressure indication

1.2.1. Cold Cathode Discharge Gauge:

Consolidated Vacuum Corporation

Type No. GPH-100 A.

Operating range from 25×10^{-3} mm of Hg to 1×10^{-7} mm of Hg

1.3. Shut off valves

1.3.1. Vactronics Corporation

Type CV50L

Bellows seal valve

One half inch tubing solder connection

Maximum operating temperature - 200°F

2. Precautions

2.1. Vacuum pumps

2.1.1. Mechanical pump

If the pump rotor should stall during start-up, shut off the motor and free the pump rotor manually. Restart motor.

2.1.2. Diffusion pump

2.1.2.1. Heater input

Coil requirement is 135 watts. The resistance is 92 ohms, so that a drop of 110 volts across the coil will provide the required wattage. A rheostat is included to compensate for line voltage above 110 volts.

2.1.2.2. Shut-down

Under no circumstances should the diffusion pump be exposed to high pressure (above 1×10^{-1} mm of Hg) when the oil is hot. See Section 3.2 for procedure for shutting down.

2.2. Vacuum Gauge

2.2.1. A high voltage potential is inherent in the operation of the discharge gauge (up to 4400 volts). DO NOT touch the leads when the power source is energized. When the power source is deactivated, DO NOT touch the leads until they have been grounded.

2.2.2. When making the spark plug type connection, only axial force is to be applied or the glass-to-metal seal may be fractured.

2.2.3. Although the maximum pressure indication is 25×10^{-3} mm of Hg the gauge will not be damaged by very short exposures to higher pressures. Prolonged exposures (up to atmospheric pressure) will cause unnecessary contamination and result in a shortened gauge life.

3. Operation

(NOTE: The sequence of operation is referenced to the attached schematic diagram and the corresponding identification tags on each valve.)

3.1. Initial conditions:

a) Valve #1 open

b) Valve #2 open

c) Valve #3 closed

d) Valves #4 open if connected to system to be evacuated or closed if only the manifold is to be checked.

e) Diffusion and mechanical pumps off.

f) Fan off

g) Vacuum gauge off

3.1.2. Roughing stage

3.1.2.1. Turn on mechanical pump and allow it to run continuously. DO NOT start the diffusion pump until the system pressure is 25×10^{-3} mm of Hg. This can be determined by periodically turning the discharge gauge for short periods (5 to 10 seconds) and observing the point at which the pressure indicated is 25×10^{-3} mm or less. A rough indication of the pressure is the change in pitch of the sound of the mechanical pump as the pressure drops from atmospheric to the micron range.

3.1.3. High vacuum operation

3.1.3.1. When the pressure is 25×10^{-3} mm or less

a) Turn on the fan

b) Turn on the diffusion pump

3.1.3.2. When the diffusion pump boiler becomes too hot to touch,

a) Close valve #1.

b) Open valve #3.

(NOTE: When the diffusion pump is first turned on, gas will be evolved from the oil, temporarily raising the system pressure. If the pressure exceeds 25 x 10^{-3} mm, turn off the vacuum gauge and monitor the pressure periodically until it falls below 25 x 10^{-3} mm. When the pressure drops below this pressure, the gauge may be left on continuously.)

3.2. Shutting down

3.2.1. a) The mechanical pump is to remain on.

b) Close valve #4

c) Turn off vacuum gauge power supply

d) Turn off the diffusion pump

e) The fan is to be left on.

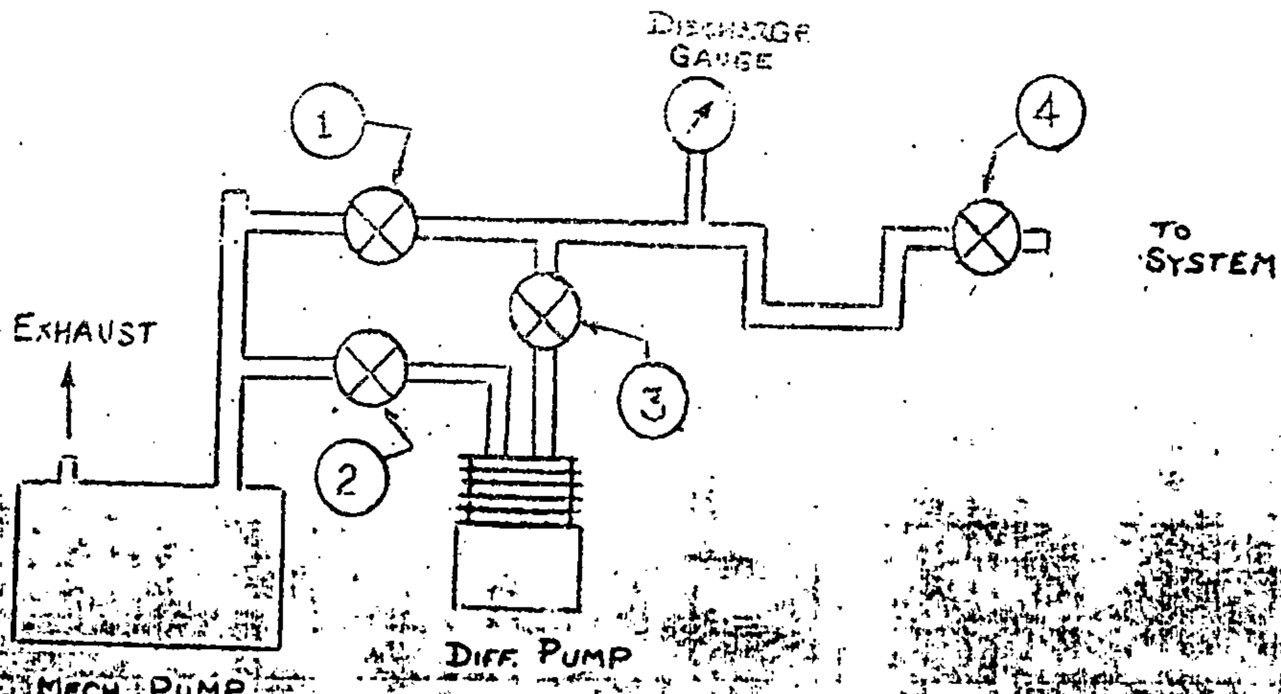
3.2.2. When the diffusion pump boiler is cool enough to touch,

a) Turn off the fan

b) Close valves #2 and #3

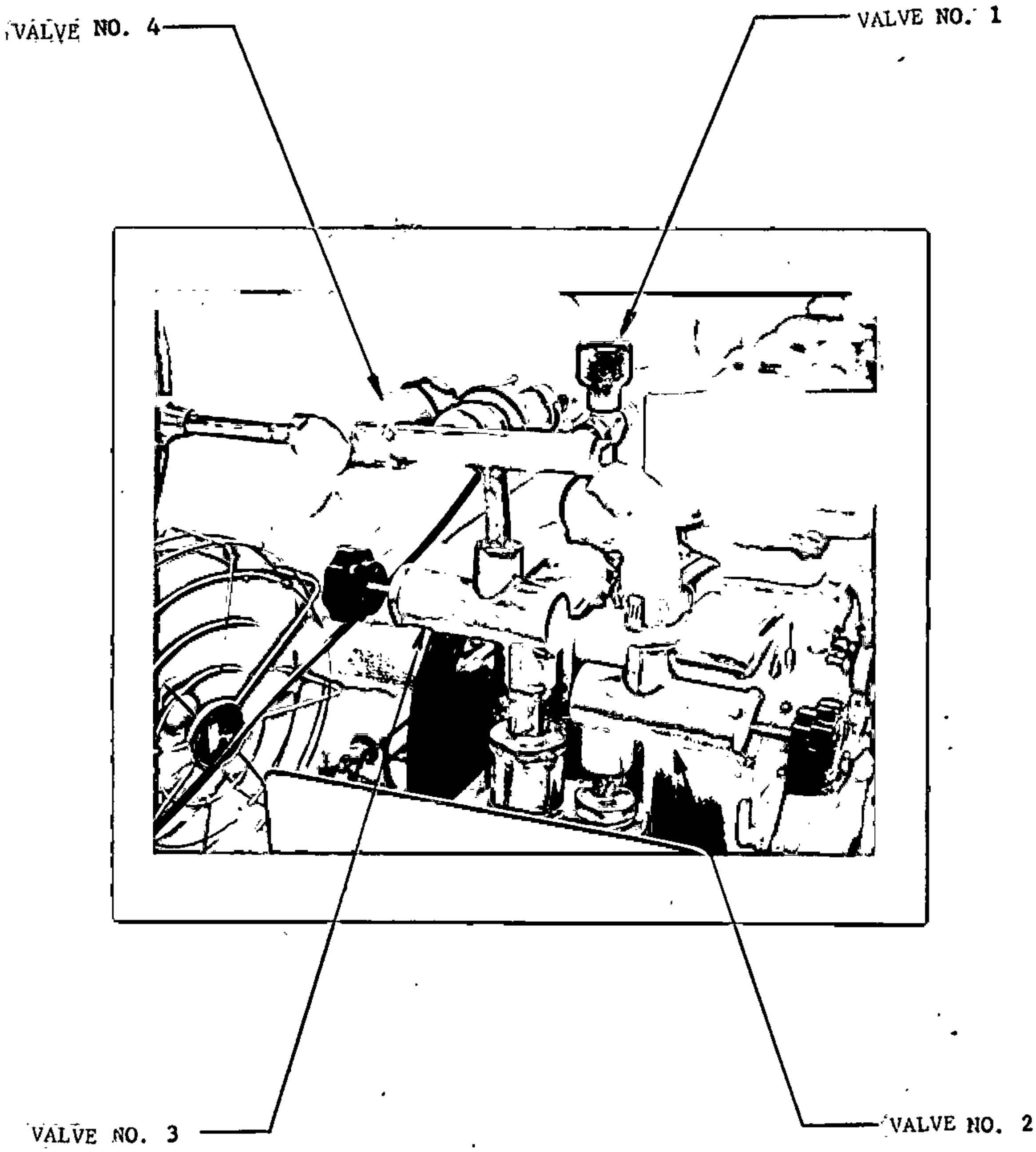
c) Turn off the mechanical pump

(NOTE: Valves #2 and #3 are closed only to prevent contamination of the diffusion pump oil. If necessary, the pump may be disconnected for servicing when the boiler is cool.)


DISCHARGE
GAUGE
1
4
TO
SYSTEM
EXHAUST
3
2
MECH. PUMP
DIFF. PUMP

PROTOTYPE PUMPING SYSTEM

VALVE DETAIL



SPARE PARTS FOR VACUUM PUMPING SYSTEM

I. Mechanical Pump (HYVAC-2)

a) One complete oil change (one quart)

b) One "V" belt

c) Instruction Booklet

II. Diffusion Pump (VMF-11)

a) One complete oil change (55 gms. of Cencoil "E")

b) One heater (C.V.C. No. 63293)

c) One dozen drain gaskets (C.V.C. No. 26441)

d) Plastic tubing (for filling pump)

e) Instruction booklet

III. Vacuum Gauge (GPH 100 A)

a) Instruction booklet

IV. Miscellaneous

a) One Hoke valve (A434)

b) Two Hoke adaptor fittings (S-25)

c) One Bellows seal valve stem assembly for Q.E.D. valves (CV50)

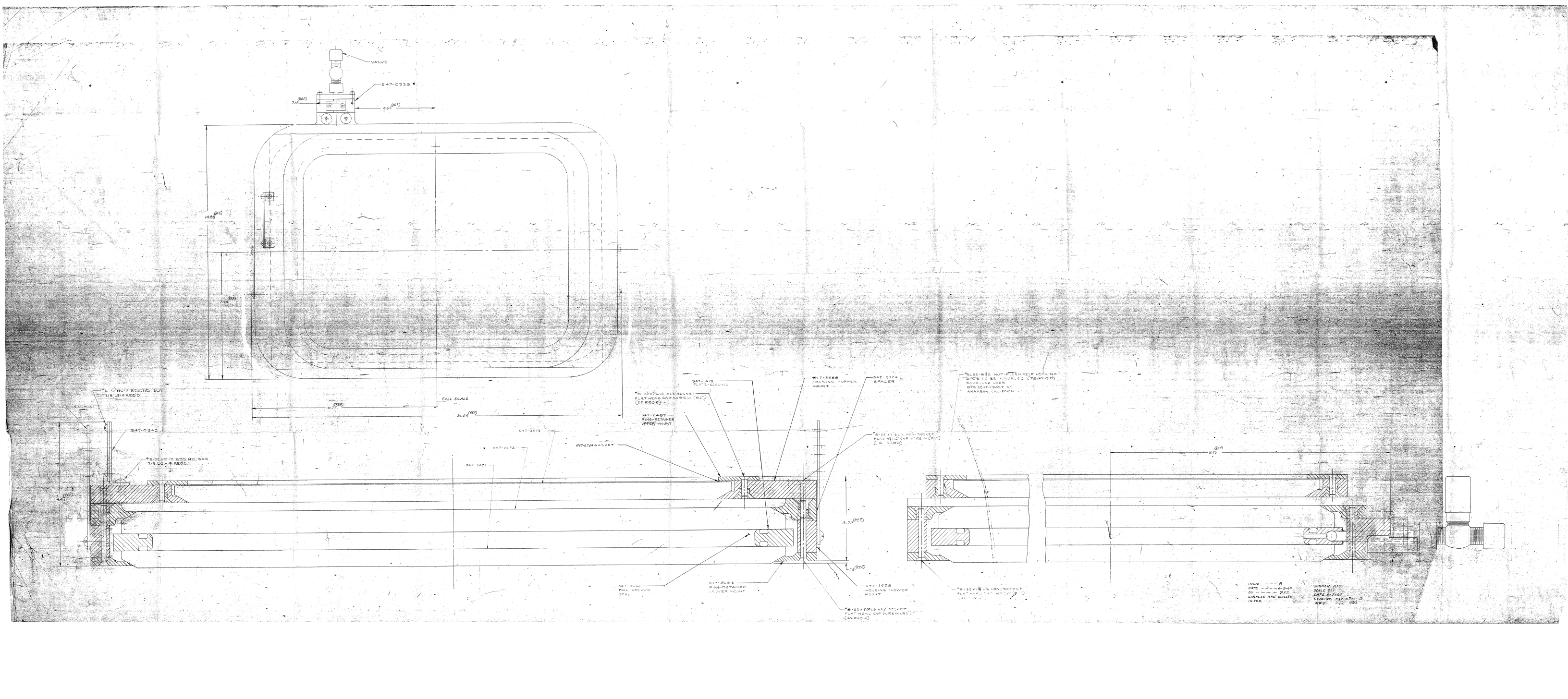
d) Eight ounces of high vacuum grease

e) Two ½" flare tubing Union fittings

f) Fifteen feet of ½" copper tubing

g) One seal-stix high vacuum wax

h) One adaptor fitting, ½" flare tube to S-25 Hoke fitting


VALVE
FULL SCALE
SLSZ-832 NUT-FLUSH SELF LOCKING
DIA. B TO BE KNURLED (78 REQ'D)
SHUR-LOK CORP.
878 SOUTH EAST ST.
ANAHEIM, CALIFORNIA
#8-32 x 2.00 LG HEX SOCKET
FLAT HEAD CAP SCREW (82°)
(20 REQ'D)
ISSUE ---- A
DATE ---- 6-3-60
BY ---- P.F.F.
CHANGES ARE CIRCLED
IN RED.
WINDOW ASSY
SCALE 2:1
DATE 4-5-60
DWG. NO. 547-0593-2